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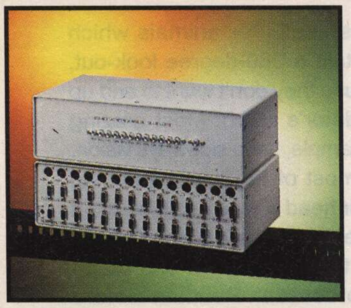

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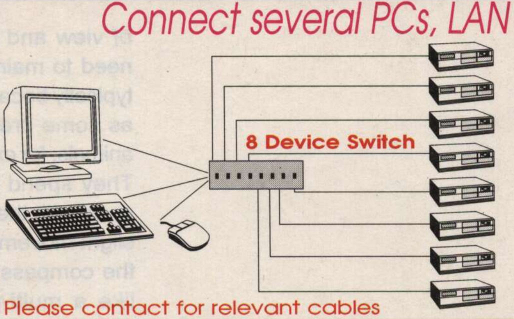

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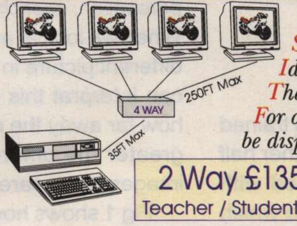

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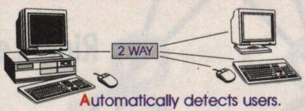

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# Seeing is believing

**If you've ever wondered how they make those 3D stereogram images that seem to be popping up in every shop and street corner, then wonder no longer. Mike Liardet explains how they work, and shows you how to create them for yourself.**

Even the most unobservant *PCW* reader will have noticed that human beings and other animals are equipped with two eyes. Less obvious, however, is that animal vision can be divided neatly into two separate categories, each working quite differently and fulfilling different needs for the various species.

While some animals have both eyes facing forwards so that they can be trained simultaneously on an object, the other half of the animal kingdom is equipped with eyes on opposite sides of the head which face sideways. For these animals, each eye provides its own independent half of the overall picture, and there's only a very small area that they can see with both eyes.

Sideways vision gives a very wide field of view and is useful for animals which need to maintain a 360-degree look-out, typically because they don't want to end up as some predator's lunch. Most grazing animals, for example, have sideways vision. They spend most of the time munching away with their head down, but if there's a slight movement from almost any point of the compass they can spot it and be off like a multi-processor Pentium before anything can gobble them up.

Forward-facing eyes are useful to predators, which need accurate vision to pounce on their prey, and also for animals such as apes which spend most of their time swinging around on branches. Being related to apes, humans also come into this category, even though nowadays we spend more time swinging in pubs and clubs rather than trees.

In exchange for a narrower field of view, forward vision gives accurate depth perception, especially at close to mid-range. When we look at an object we see a slightly different picture in each eye, and our brain can interpret this difference to determine how far away the object is. In general, the greater the difference between the two images, the nearer the object.

Fig 1 shows how the image of an object is projected onto the retinas of the left and right eyes when viewed in different positions. The left-hand diagram shows what happens when the object is quite close by and the right-hand shows the situation when it is further away. Notice that the image is actually projected upside down on each retina — the brain automatically compensates for this and we "see" it the right way up. (This capability is not "hard-wired" — experiments have shown that after a few days of wearing inversion spectacles the brain can make the necessary corrections so that everything is seen the right way up again.)

Of course, the visual

1

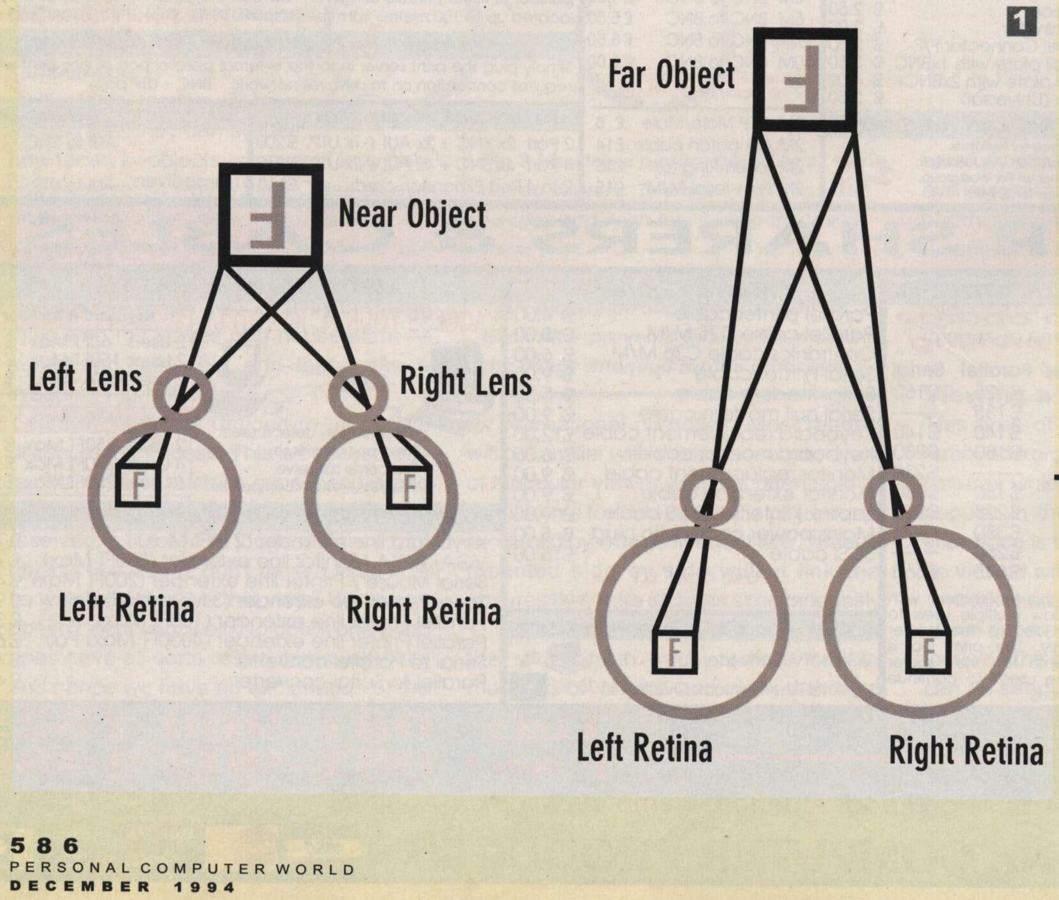


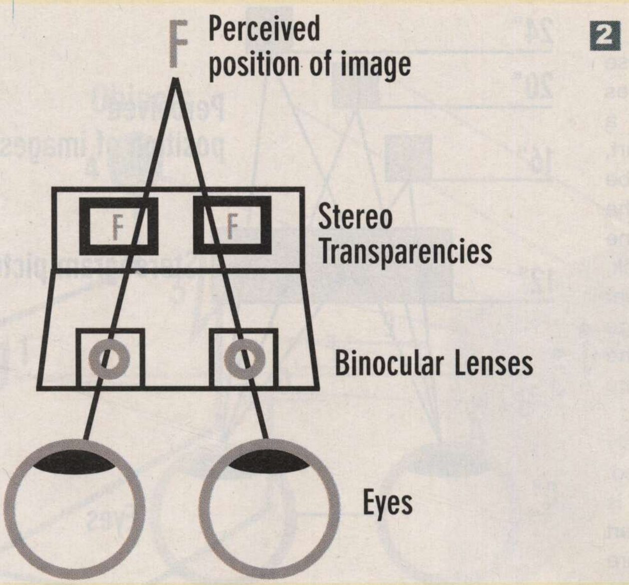
**Fig 1** ***When an object is nearby there are considerable differences between the images projected onto the retinas of the left and right eyes. As the object is moved further away, there is less and less difference***

system is a lot more complicated than we have shown here. For example, we have ignored the fact that distant objects create a smaller image on the retina. Also, to a certain extent we all have the capability to go cross-eyed — that is, to point each eye independently towards a close object — but we have shown the eyes always looking squarely ahead for both situations. Nor have we shown how the eye compensates for varying distances by changing the focus of the lens.

The important point to note is that for the near object, the two eyes each see a marked difference in the image. Even though it is placed squarely in the middle of the field of view, when it is close-by its image is off-centre on both retinas — way to the left of the left eye's retina and to the right of the other's. For the more distant object there's less of a difference, with the image not far off the centre of the retina with both eyes. When the object is at "infinity", which for all practical purposes can be taken as a distance of ten metres or more, each eye sees the same image.

No doubt, readers will have noticed that they can still tell how far away objects are even if they only use one eye; so why is this? Close an eye and experiment. Touch some near-by objects on a desk-top and you will find that you can pinpoint them almost as easily with one eye as with two. Then try the same thing with the leaves of a house-plant — something fairly big and leafy, like a Weeping Fig, will do.

It's surprisingly difficult to judge the distances in this case. This is because with familiar objects such as cups, pencils and books we can use the size of the image received in the eye to judge distance, but objects like leaves don't have a fixed size so with only one eye this visual depth cue doesn't work very well. No doubt one-eyed apes have all sorts of problems with this, and hence we have an explanation of the antipodean expression "out of his tree".



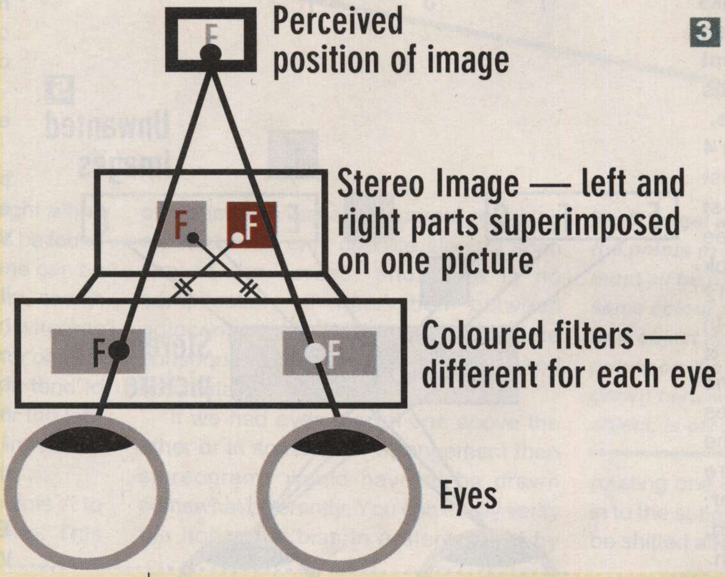

3
F
Perceived position of image
F
F
Stereo Image — left and right parts superimposed on one picture
F
F
Coloured filters — different for each eye
Eyes

**Fig 2** *Viewing a picture taken by a stereo camera. There are two separate images and each eye sees only one of them*

**Fig 3** *Viewing a specially constructed "3D" picture through coloured filters. Each filter prevents the eye from seeing the image intended for the other eye*

It's possible to exploit the interesting properties of our stereoscopic visual system for recreational purposes. Most readers will be familiar with the stereoscope, a kind of binocular viewer which is often sold as a children's toy. Stereoscopic pictures are produced by what is in effect two cameras mounted side by side with a link that ensures they take pictures simultaneously.

Usually, transparency film is used and the slides from each camera can be mounted on a card and viewed through the stereoscope. The general arrangement is shown in Fig 2. Even though they took a picture at the same instant, the two cameras produce slightly different images. When seen through the viewer, these differences are interpreted by the brain to produce an effect which makes us see the image with the depth information preserved.

This stereo viewing mechanism could in principle be extended to motion video. With two video cameras and a binocular video viewer we could see full 3D video films. I have never seen this done in practice, although of course the head-gear for Virtual Reality systems does display computer-generated stereo images in this fashion. Unfortunately, virtual reality images are typically less interesting than films shot from real life. Perhaps with the plummeting price of video technology some Hollywood mogul will produce a film in this way — it would certainly be stunningly lifelike.

With the aid of special filter glasses it is also possible to see a 3D effect from just one original picture. Fig 3 shows how this is done. With a red filter over the left eye and a green filter over the right, the left eye is unable to see any red in the original and the right eye cannot see green. By carefully superimposing the left and right eye images onto the same picture but using contrasting colours for each, it can be arranged that each eye can view the picture, but each sees only the image intended for it. The brain combines the two images to see a picture in 3D.

### Viewing a stereogram

This type of 3D image is but one step removed from the "Magic Eye" stereogram pictures which have become enormously popular in the last few months. The key difference is that stereogram pictures can be viewed without any special apparatus.

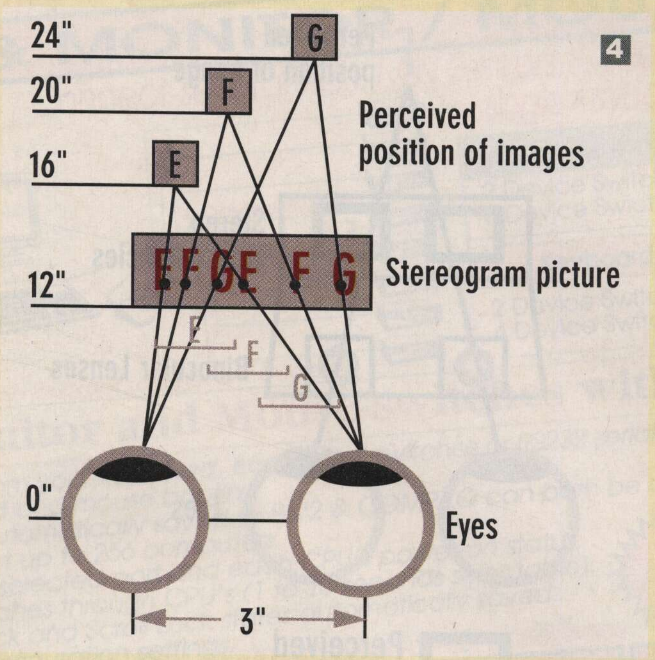
It takes practice to see the image lurking within a stereogram. Instinctively the eyes focus on the plane of the page, and all that can be seen is the random wallpaper-like pattern of dots used to construct the picture. To see the underlying image in a stereogram you must focus your eyes behind the page.

Even with experience in these matters, for most people it takes some time to perceive a stereogram image. For a start, the resulting scene may not be at any fixed position behind the paper. Some objects in the scene may be only a few inches back, while other parts might be further away. Reflections on the page and creases and flaws in the picture itself can also distract the eye.

Fig 4 shows approximately how a stereogram is constructed. For any one object, each eye is actually looking at a different part of the paper. Once the eyes are focused correctly, the brain does not realise this. Instead it thinks that a real object is being seen and interprets the different images seen by each eye as depth information in the scene.

The distances given in Fig 4 are representative of most stereogram pictures. Most humans have eyes around three inches apart, and generally look at pictures at a distance of 12 inches or so from the page. In this case the perceived letter E is shown at four inches behind the page, with the F at eight inches and the G at 12. Notice that the two E's on the paper are comparatively close together, while the F's are further apart, and the G's further apart again.

Bearing this in mind, it is possible to produce a very crude stereogram effect without recourse to anything more sophisticated than an algorithm which places pairs of images along a line, with far objects being widely separated from each other, and near objects close together. For example, a crude stereogram can be constructed very quickly by displaying the text string E__F__G_E____F_______G in a large enough font.



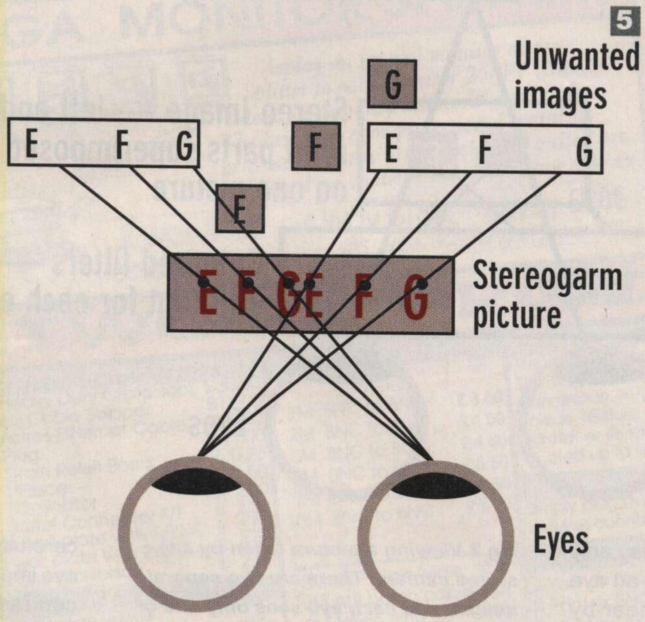


**Fig 4** *How a stereogram picture is viewed. Notice that on the page, the left and right "shadows" of images that appear to be near (i.e. the E's) are closer together then those which appear to be distant*

**Fig 5** *Interference between images. The right eye can look at parts of the stereogram which we would ideally like to reserve for the left eye, and vice versa*

Unfortunately, the proper production of a stereogram is not quite as simple as this. Fig 5 shows what happens with this simplistic scheme. It can be seen that the right eye can see parts of the stereogram which, in the context of the scene in Fig 4 at least, we would like to reserve exclusively for the left eye. Likewise, the left eye can see parts of the stereogram which we would ideally like to reserve for the right eye. If the stereogram isn't constructed properly, then these spurious extra images will spoil the scene.

It's possible to get round this problem by using colour (or grey-tone shading) in the picture. Anyone who has seen a stereogram will have noticed that the portrayed objects generally have the correct shape and perspective, but never have the shading and colouring of a real object. Viewed as a picture in the normal way the stereogram might have some interesting swirls and whorls, like a wallpaper pattern, but this pattern is also imposed on the underlying object.

The wallpaper effect may look interesting, but it's hardly lifelike. For example, on initial inspection a stereogram may appear as a repeated pattern of rosebuds, with some irregularities. Lock into the underlying image and you might see a car, but not an ordinary car. It will be a car completely covered in rosebuds — tyres, windscreen and everything.

This bizarre patterning is not put there purely for your entertainment when you are viewing a stereogram. It is essential to the workings of the illusion. Fig 6 shows how this happens. Suppose the four objects numbered 1 to 4 are to be included in a stereogram. We start by joining a point in object 1 to the left eye. This crosses the screen at point A.

### Going green

We can choose any colour we like for point A — for example, the desired colour of the point, as taken from the original object 1, or any other colour, e.g. green. Once this colour is chosen it must be assigned to parts of other objects in the stereogram scene as well: point B on the screen must also be green, because this is the point at which the right eye sees the green point in object 1. Obviously, the left and right eyes must see the same thing when they are looking at the same point, so there is no choice in the matter — point B must be green.

Point B is also seen by the left eye, when it is looking in that direction. In this particular case this happens when it is looking at a point in object 2. Again, this means the point in object 2 which lines up with the left eye must be assigned the colour green, no matter what colour we would ideally like to choose for it

The right eye sees this point in the object at position C on the screen, and so this too must be drawn in green. Colouring point C in green has a knock-on effect further down the line and by continuing this line of reasoning we end up with a row of five points, labelled A to E, all coloured green. In this case the sixth point, F, which is where the right eye would see a point in some fifth object, is off the screen, and it just can't be drawn.

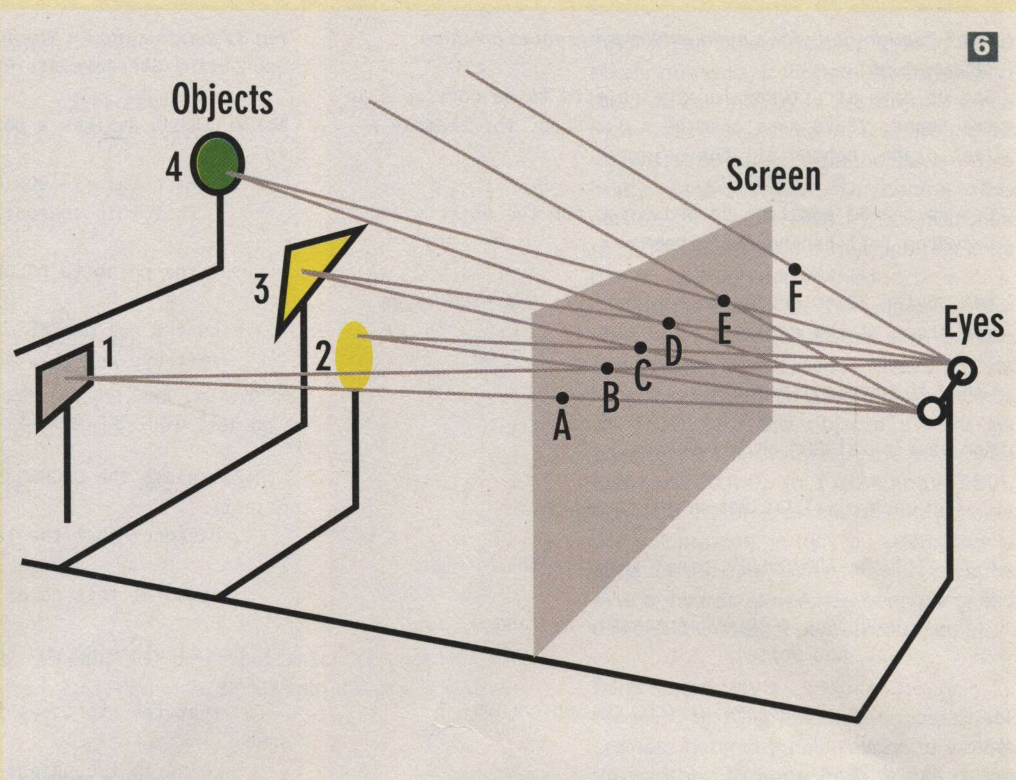


**Fig 6** *To get a proper stereogram effect the points in the four objects shown here must all be plotted on the screen with the same colour (or pattern). Notice that the four object points actually occupy five points on the screen. The sixth point, drawn between the right eye and a fifth object, is off the edge of the screen*

To complete the stereogram for the scene in Fig 6, all the remaining points on the screen would have to be plotted, but the principles are much the same. The only extra player is a backdrop, which is needed some way behind all the objects, to catch any parts of the scene which aren't inhabited by the objects themselves.

If the plotting algorithm scans the screen from left to right when performing its machinations, it will be found that objects to the left of the scene can be coloured with their original colours, or with rosebud emblems or whatever, whereas there is less choice in the matter for objects on the right. Objects on the right tend to 'inherit' whatever was chosen for the left-hand side, although there are inevitably some distortions in what they get.

Notice that in Fig 6, all the points A to E lie on the same horizontal line. This demonstrates that a stereogram colouring method need only operate along a scan line of the screen, and there is no complication of interaction between adjacent rows. This is an immediate consequence of our eyes being aligned horizontally.

If we had eyes placed one above the other or in some other arrangement then stereograms would have to be drawn somewhat differently. You can easily verify the horizontal bias in a stereogram by rotating one once your eyes have locked in to the scene. The stereogram need only be shifted a few degrees off the horizontal

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***Fig 7** Pseudo-code for a main calling program to produce stereograms*

```
Set up data structures for the objects to be portrayed in
the scene. There must also be a backdrop, for example a
flat plane, behind all the objects.

Set up the 3D position co-ordinates for the objects and
backdrop (all behind the screen).

Set up the 3D co-ordinates for the left and right eyes
(in front of the screen).

Clear the screen to white.

For each pixel ROW on the screen

   For each pixel COLUMN on the screen

       If the ROW/COLUMN pixel is white then

           Choose a COLOUR (possibly at random, but
             not white)

           Call StereoPoints(ROW,COLUMN,COLOUR)

       end If

   Next COLUMN

next ROW

Finish
```

***Fig 8** Pseudo-code for StereoPoints subroutine*

```
Subroutine StereoPoints(ROW, COLUMN, COLOUR)

While COLUMN defines a point on the screen

    If the point (ie ROW/COLUMN) is not White then
        Exit this subroutine.

    Set the point to COLOUR

    Find the nearest object which is in line with the
      left eye and this point. This will be the back-
drop
      if no other object is in line.

    Calculate the COORDS of the position in the
object/
      backdrop that the left eye actually sees when
it
      looks at this point on the screen

    Re-calculate COLUMN to give the point on the
screen
      that the right eye looks at when it sees this
same
      point in the object (ROW is unchanged)

    If there are any nearer objects blocking the
right
        eye's view then Exit this subroutine

End While

End Sub
```

before the three-dimensional effect is lost.

Figs 7 and 8 give pseudo-code for generating stereograms. Potentially, the 3D modelling of the objects to be portrayed is the most difficult part of the implementation. Commercially produced stereograms contain elaborate curved objects, which are presumably (I am not privy to their secrets) developed using sophisticated CAD software. It is much easier to model a "cardboard cut-out" scene, where each object is essentially a 2D drawing, oriented in parallel to the screen.

Fig 9 shows a reasonable co-ordinate scheme, which is in line with the way most programming languages manipulate screen co-ordinates. The top left-hand corner of the screen is the origin, with the x-axis measuring distance across the screen and the y-axis measuring distance downwards. The z-axis is perpendicular to the plane of the screen, with the eyes having positive z co-ordinates, and all the objects and backdrop with negative z values.

It is not too difficult to arrive at some reasonable co-ordinates for the eye positions and the various objects, although these settings aren't critical by any means. These calculations can, for example, be based on a typical PC video display with a resolution of 1024 x 768 pixels.

Most monitors have a 14in diagonal so

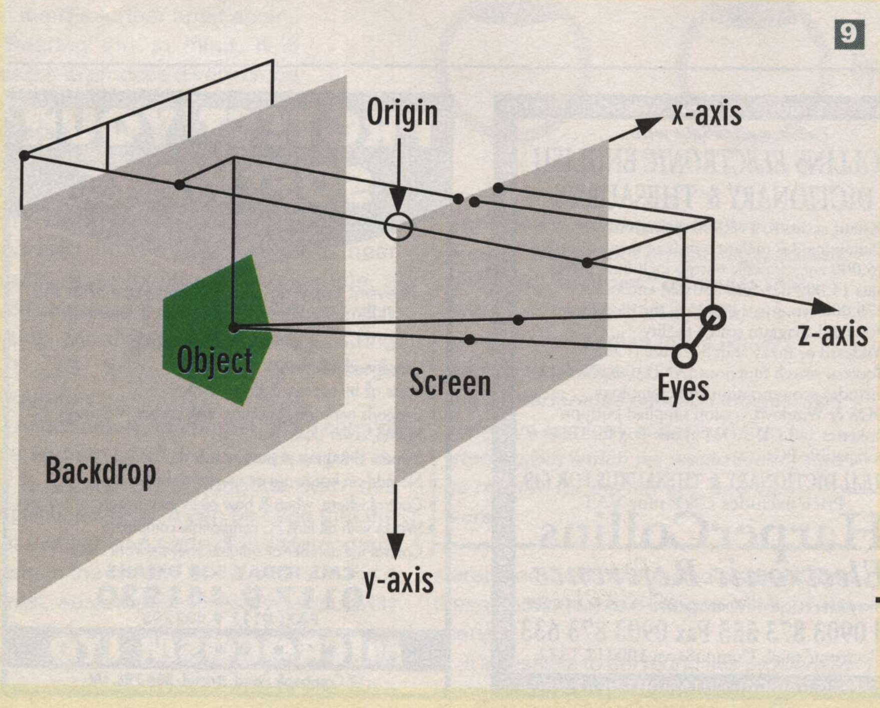

**Fig 9** *Co-ordinate scheme for implementing a stereogram program*

*Fig 10 A crash course in Co-ordinate Geometry*

```
Co-ordinate Variables
Left Eye:             (xLeftEye,yEyes,zEyes)
Right Eye:            (xRightEye, yEyes,zEyes)
Point on screen:      (X, Y)
Point in object:      (xObj, yObj, zObj)
Position of backdrop: (..,..,zBack)

Basic Function for Solve()

function Solve(xValue,x1,y1,x2,y2)

'Gets equation of line through (x1,y1) and (x2,y2) and
'finds value 'Solve' so that (xValue,Solve) lies on it

Solve = y1 + (xValue - x1)*(y2 - y1) / (x2 - x1)

End Function

Using Solve()

Q: Given a point (X,Y) on the screen, and an object which is known to be
in the zObj plane, what row (ie y coordinate) in the object are the eyes
looking at?

A: yObj = Solve(zObj,zEyes,yEyes,0,Y)

Q: Given a point (X,Y) on the screen, and an object which is known to be
in the zObj plane, what column (ie x coordinate) in the object is the left
eye looking at?

A: xObj = Solve(zObj,zEyes,xLeftEye,0,X)

Q: Given a point (xObj,yObj,zObj) in the object, where on the screen (ie
(X,Y) coordinate)  does the right eye see it?

A: X = Solve(0,zObj,xObj,zEyes,xRightEye)
   Y = Solve(0,zObj,yObj,zEyes,yEyes)
```

1024 x 768 pixels equates to roughly 90 pixels per inch. It is quite reasonable to assume that the eyes are around three inches (270 pixels) apart, and around 12 inches (1080 pixels) from the screen. The bridge of the nose should be central to the screen (i.e. with co-ordinates (512,384,1080)) and so the eye positions can be calculated from this.

The backdrop, at the rear of all the objects at the back of the screen, can conveniently be 12 inches away from the screen as well, which gives its z co-ordinate as -1080. All the objects should be positioned somewhere in the cube with diagonal (0,0,0) to (1024,768,-1080), although to some extent objects outside this volume can, in fact, be seen. This is because the eye's cone of vision expands ever outwards after it has been funnelled through the smaller screen window.

### In perspective

Finally, Fig 10 gives the necessary co-ordinate geometry calculations to enable the method to jump from points in the screen to points in the object, and then back to the screen, lining up with the left or right eyes as appropriate. These calculations also produce a proper perspective projection of the scene, so that more distant objects appear smaller — which is at it should be.

### PCW Contacts

**Mike Liardet** is a freelance programmer and writer. He can be contacted via the usual *PCW* address or via email as **mliardet@cix.compulink.co.uk**

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Prices include a desktop or mini tower case, Cirrus 5428 SVGA 1Mb VLB Accelerator colour card, 14in SVGA 1024x768 monitor, 4Mb of RAM, 1.44Mb floppy drive, VLB I/O card, keyboard, 3-button mouse, Windows 3.11, DOS 6.2 (full manuals and discs provided), 12 Months OSM warranty (mainland UK only). *All 486 boards are DX4 compatible and are fitted with ZIF sockets.*

**M/M - Multimedia option** - as PC spec., plus SoundBlaster Pro 16 Value, Panasonic 562 CD-ROM & Speakers

| Dabs direct PCI PC's | IDE Systems | | | SCSI Systems | | |
|---|---|---|---|---|---|---|
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| Pentium 60Mhz PCI | 1265 | 1325 | 1535 | 1750 | 1925 | 2110 |
| Pentium 66Mhz PCI | 1345 | 1405 | 1615 | 1835 | 2010 | 2195 |
| Pentium 90Mhz PCI | 1465 | 1525 | 1735 | 1950 | 2125 | 2310 |

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| 9486 Multimedia | 949 | 989 |
| 9486 DX2 50/130Mb | 939 | 984 |
| 9486 DX2 50/214Mb | 982 | 1027 |
| 9486 DX2 50/340Mb | 1029 | 1064 |
| 9486 DX2 66/214Mb | 1115 | 1160 |
| 9486 DX2 66/340Mb | 1160 | 1205 |

*All prices include monitor, keyboard, mouse, DOS, Windows, PFS WindowsWorks (installed versions).*

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| 151 FS | 339 | 171 FS | 658 |
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| | | | |
|---|---|---|---|
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| 4/25S M240/w | 752 | 4/33S M1 | 515 |
| 4/33S M200/w | 664 | 4/33S M340/w | 740 |
| 4/33 M1 | 761 | 4/33 M120/w | 888 |
| 4/33 M240/w | 931 | 4/33 M340/w | 1016 |
| 4/50 M1 | 770 | 4/50 M200/w | 824 |
| 4/50 M340/w | 900 | 4/66 M1 | 723 |
| 4/66 M200/w | 873 | 4/66 M340/w | 951 |
| 4/66 M525/w | 1010 | 4/100 M1 | 1052 |
| 4/100 M200/w | 1205 | 4/100 M340/w | 1460 |
| 4/100 M525/w | 1340 | | |

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|---|---|---|---|
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| Slim 486/50 4/240 | 720 | Mini T' 486/66 4/240 | 670 |

*Inc PC DOS 6.3, Win 3.1, IDE HDD, Monitor & Mouse*

## PORTABLES

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| 4/33c M170 | 1189 | 4/33c M250 | 1360 |

All Aero's now come with 3.5" 1.44Mb floppy drive.

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| Omnibook 530 | 1039 |

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| T1910/200 | 1449 | T1910CS/120 | 1539 |
| T1910CS/200 | 1635 | T1950CT/200 | 2320 |
| T1950CT/320 | 2574 | T2400CS/250 | 2249 |
| T2400CT/320 | 2999 | T3400CT/120 | 2649 |
| T3600CT/250 | 3164 | T4600C/200 | 3069 |
| T4600C/320 | 3319 | T4700CT/200 | 3359 |
| T4700CT/320 | 3599 | T4800CT/500 | 4175 |
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|---|---|---|---|
| PenPad PDA 600 | 219 | NC200 | 245 |

### APPLE

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|---|---|---|---|
| Newton Message Pad | 357 | Newton MP 110 | 385 |
| 2Mb Storage Cart. | 167 | Leather Case | 39 |

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| 95LX Connectivity pack | 54 | 1/200LX Connect pack | 75 |
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| Model LZ | 99 | LZ64 | 125 |
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| 256k Datapak | 109 | Format 256k | 17 |
| Formatter | 39 | Mains Adapter | 10 |
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| Series 3 128k Model | 108 | Series 3 256k Model | 145 |
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| Games Pack 3 | 25 | Flight Manager | Call |
| Psion Money | 40 | Spellcheck/Thesaurus | 29 |
| 128k Flash SSD | 27 | 128k RAM SSD | 37 |
| 256k Flash SSD | 40 | 512k RAM SSD | 89 |
| 512k Flash SSD | 65 | 1Mb RAM SSD | 189 |
| 1Mb Flash SSD | 89 | 2Mb Flash SSD | 139 |
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|---|---|---|---|
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|---|---|---|---|
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| Arcus Plus & Trans | 2340 | | |

### EPSON

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|---|---|---|---|
| GT6500 Par | 453 | GT6500 SCSI | 480 |
| GT8000 Par & SCSI | 625 | GT9000 Par & SCSI | 740 |
| GTx6500 Par+PS LE | 520 | GTx6500 SCSI+PS LE | 585 |
| GTx8000 Par+PS LE | 675 | GTx8000 SCSI+PS LE | 735 |
| GTx9000 SCSI+PS LE | 895 | GTi6500 SCSI+PS full | 729 |
| GTi8000 SCSI+PS full | 885 | GTi 9000 SCSI+PS full | 1039 |

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| Scanjet IIcx ISA | 678 | Scanjet IIcx MCA | 678 |
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### LOGITECH

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|---|---|---|---|
| Scanman 32 DOS+OCR | 60 | Scan32 Win+OCR | 69 |
| Scanman 256 | 99 | S256 MCA | 194 |
| Scanman Colour | 208 | Fotoman + | 375 |
| Scanman Easytouch | 137 | PowerPage | 319 |

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| WY-55 | 249 | WY-55ES | 269 |
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| WY-325ES | 409 | WY-370 | 699 |

Please advise screen colour (Green/Amber/White).

All prices include keyboard please specify type.

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| Pentium 90 | 705 | | |

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|---|---|---|---|
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| Cherry Non-Click k/bd. | 32 | MS Natural k/bd. | 69 |
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| Twin FD Cable | 3 | Adaptors | from 5 |

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| 1Mx32 (4Mb) 72pin | 99 | 2Mx32 (8Mb) 72pin | 144 |
| 4Mx32 (16Mb) 72pin | 365 | 8Mx32 (32Mb)72pin | 749 |
| 1Mx36 (4Mb) | 110 | 2Mx36 (8Mb) | 210 |
| 4Mx36 (16Mb) | 399 | 8Mx36 (32Mb) | 899 |
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| Generic PC Mouse | 15 | | |

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| SB Pro 16 Value | 67 | SB Pro 16 MCD | 103 |
| SB Pro 16 ASP SCSI2 | 139 | SB Pro SCSI - 2 | 118 |
| SB 16 ASP MCD | 119 | AWE 32 | 175 |
| GameBlaster CD16 | 259 | WaveBlaster | 139 |
| VideoBlaster SE | 188 | VideoBlaster Dev Kit | 55 |
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|---|---|---|---|
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| Kelvin VLB 1Mb | 103 | Sound Drive 16EZ | 85 |
| SoundDrive EZ SCSI | 95 | | |

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| Space Quest IV | 29 | Space Series Apollo | 25 |
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| Theme Park | 29 | Toolworks Ref Library | 67 |
| Video Space Cube | 31 | World Atlas 4 | 39 |

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Bracketed figure is capacity in Mb.

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|---|---|---|---|
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| CFA540A (540) | 190 | CFA810A (810) | 312 |
| CFA1060A (1Gb) | 419 | | |

### CONNER SCSI

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|---|---|---|---|
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### MAXTOR IDE

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|---|---|---|---|
| 7171A (170) | 102 | 7245A (245) | 114 |
| 7345A (345) | 132 | 7546A (546) | 195 |

### MAXTOR SCSI-2

| | | | |
|---|---|---|---|
| 7290S (290) | 199 | 7345S (340) | 249 |

### QUANTUM IDE

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|---|---|---|---|
| LPS210A (210) | 112 | LPS270A (270) | 129 |
| LPS340A (340) | 170 | LPS540A (540) | 218 |

### QUANTUM SCSI

| | | | |
|---|---|---|---|
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| EMP540S (540) | 259 | EMP1080S (1.08Gb) | 479 |
| EMP1440S (1.4Gb) | 699 | EMP1800S (1.8Gb) | 695 |
| EMP2100S (2.1Gb) | 949 | | |

### SAMSUNG IDE

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|---|---|---|---|
| 30210A (210) | 110 | 3212A (426) | 149 |
| 30560A (560) | 189 | | |

### SEAGATE IDE

| | | | |
|---|---|---|---|
| ST3290A (260) | 121 | ST3391A (341) | 156 |
| ST3491A (425) | 159 | ST5660A (528) | 211 |

### SEAGATE SCSI-2

| | | | |
|---|---|---|---|
| ST3390N (340) | 275 | ST5660N (528) | 380 |
| ST31200N (1.05Gb) | 505 | ST12400N (2.1Gb) | 882 |
| ST12550N (2.1Gb) | 909 | ST41800N (9Gb) | 2899 |

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|---|---|---|---|
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| AC2540 (540) | 211 | AC2700 (700) | 335 |
| AC31000 (1Gb) | 426 | | |

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|---|---|---|---|
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| 1542c | 139 | 1542c kit | 178 |
| 2842c kit | 179 | 2940 PCI | 205 |
| 2742 Eisa kit | 295 | 2940w | 275 |

*User knowledge is assumed when bare hard drives are supplied.*

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|---|---|---|---|
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| 250Mb Ext | 204 | Trakker 250Mb | 192 |
| Controller Card | 45 | Spare Tapes | 12 |

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| Fujitsu 256Mb Int | 559 |

## CD-ROM DRIVES

### CREATIVE LABS

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|---|---|---|---|
| CD-16 Upgrade Kit Int | 149 | CD-16 Discovery | 405 |
| CD-16 Professional | 399 | Easy CD-16 Ext | 419 |
| Digital Edge 3x | 519 | OMNI CD Int | 239 |
| OMNI CD Ext | 275 | MM Office kit | 439 |

### MITSUMI

| | |
|---|---|
| FX001DS/MS | 95 |

### NEC

| | | | |
|---|---|---|---|
| 2xi | 120 | 3xi int | 235 |
| 3xp | 260 | 3xe | 320 |
| 4x Pro | 545 | AT Interface | 62 |
| MCA Interface | 79 | Parallel to SCSI (Port) | 90 |

### PANASONIC

| | | | |
|---|---|---|---|
| CR562 kit | 105 | CR503 SCSI | 139 |
| CR503 + Adapt1515 | 195 | AT interface | 10 |

### SONY

| | | | |
|---|---|---|---|
| CDU33A & I/f | 109 | CDU31A Starter Kit | 239 |
| CDU7305 Comp Kit Ext | 285 | CDU31A Int | 129 |
| CDU31A Comp Kit | 375 | | |

### TOSHIBA

| | | | |
|---|---|---|---|
| XM3401B Int | 199 | XM3401S Ext | 359 |
| KT3104SA Int | 329 | KT3401SA Ext | 409 |
| XM4104B *New* | 249 | | |

## SPEAKERS

| | | | |
|---|---|---|---|
| 0.3 watt | 10 | 12 watt Active psu | 17 |
| 25 watt Active psu | 25 | 70 watt Active psu | 35 |
| 80 watt Active psu | 41 | | |

## MONITORS

### NEC

| | | | |
|---|---|---|---|
| 2V 14" | 230 | 3V 15" | 309 |
| 4E 15" | 375 | 5E 17" | 680 |
| 5FGp 17" | 869 | 6FGp 21" | 1439 |

### PHILIPS

| | | | |
|---|---|---|---|
| 14C LR 14" | 178 | 14A NI 14" | 212 |
| 15B 15" | 270 | 15A 15" | 299 |
| Brilliance 17B 17" | 730 | 17C 17" | 462 |
| 17T 17" | 679 | 20C 20" | 929 |
| 20T 20" | 1299 | 21B 21" | 1369 |

### PANASONIC * Include 2years OSM

| | | | |
|---|---|---|---|
| TX1537 15" * | 358 | 1732 17" * | 565 |
| TDX1751 17"* | 660 | TX2103 21" * | 1408 |
| TX2032 20" * | 1199 | TDX2123 21" * | Call |

### SAMSUNG

| | | | |
|---|---|---|---|
| CVM4967T LR 14" | 175 | CVM4238 NI LR | 199 |
| CSQ4387 LR 14" | 219 | MP 5671 A4 Dtp | 329 |
| CSR5987 LR 15" | 289 | CST 7687LR 17" NI | 529 |
| CFA7689 LR 17" | 585 | | |

### SONY

| | | | |
|---|---|---|---|
| CPD-1420S 14" | 261 | CPD-15SF 15" | 305 |
| CPD-1730 17" | 675 | GDM-17SEI | 835 |
| GDM-2036S 20" | 1439 | GDM-2038 20" | 1560 |

### TAXAN

| | | | |
|---|---|---|---|
| 400 LR | 199 | 787 14" | 199 |
| 787 LR 14" | 209 | 788 LR | 225 |
| Ergovision 580 LR 15" | 312 | Ergov. 865+ LR 17" | 560 |
| Ergovision 885 LR | 650 | Ultrav. 1075 20" | 1199 |

### VIEWSONIC

| | | | |
|---|---|---|---|
| V6E LR 14" NI | 185 | V15 15" | 325 |
| 17G 17" | 610 | V17 17" | 710 |
| V20 20" | 1139 | V21 21" | 1315 |

## DISPLAY ADAPTERS

### CIRRUS

| | | | |
|---|---|---|---|
| 5420 1Mb ISA | 49 | 5428 1Mb VLB | 70 |
| 5434 1Mb VLB | 79 | 5434 1Mb PCI | 79 |
| 5434 2Mb PCI | 149 | | |

### DIAMOND

| | | | |
|---|---|---|---|
| Stealth 64 2Mb VLB VR | 235 | St 64 4Mb VLB VRam | 340 |
| Stealth 64 2Mb PCI VR | 235 | St 64 4Mb PCI VRam | 340 |
| Stealth 64 1Mb VLB DR | 110 | St 64 2Mb VLB DRam | 145 |
| Stealth 64 1Mb PCI DR | 110 | St 64 2Mb PCI DRam | 145 |
| Speedstar Pro 1Mb | 85 | Viper PCI 2Mb | 245 |
| Viper VLB 2Mb | 245 | | |

### ORCHID

| | | | |
|---|---|---|---|
| Fahrenheit+ 2Mb VLB | 168 | F'heit 64 1Mb PCI | 135 |
| F'heit 64 2Mb PCI | 175 | F'heit Pro 64 2Mb | 255 |
| F'heit Pro 64 4Mb | 359 | Kelvin EZ 1Mb VLB | 109 |
| Kelvin EZ 1Mb PCI | 109 | Kelvin 64 1Mb VLB | 119 |
| Kelvin 64 1Mb PCI | 119 | Kelvin 64 2Mb VLB | 159 |
| Kelvin 64 2Mb PCI | 159 | Celcius IIT 1Mb VLB | 145 |
| Celcius IIT 2Mb VLB | 187 | | |

## NETWORK CARDS

| | | | |
|---|---|---|---|
| **3Com** 509 | 78 | 3Com 509TP | 95 |
| 3Com 509 Combo | 75 | 3Com 529 TP | 159 |
| 3Com 579 EISA | 149 | 3Com 589 Combo | 169 |
| **DLink** 220C | 57 | DLink 220CT | 60 |
| DLink 220 CAT | 80 | DLink 220T | 57 |
| DLink Pocket LAN | 95 | **Kingston** 16bit BNC | 45 |
| Kingston RJ45 | 45 | Kingston Combo | 49 |
| NE2000 Original | 70 | | |

### XIRCOM

| | | | |
|---|---|---|---|
| BNC EtherNet | 259 | UTP EtherNet | 189 |
| BNC ENet PCMCIA2 | 169 | UTP ENet PCMCIA2 | 169 |
| Combo ENet Pocket | 199 | Combo ENet PCMCIA2 | 189 |

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